Study of acceptance of ECal detector of the HADES experiment

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Motivation

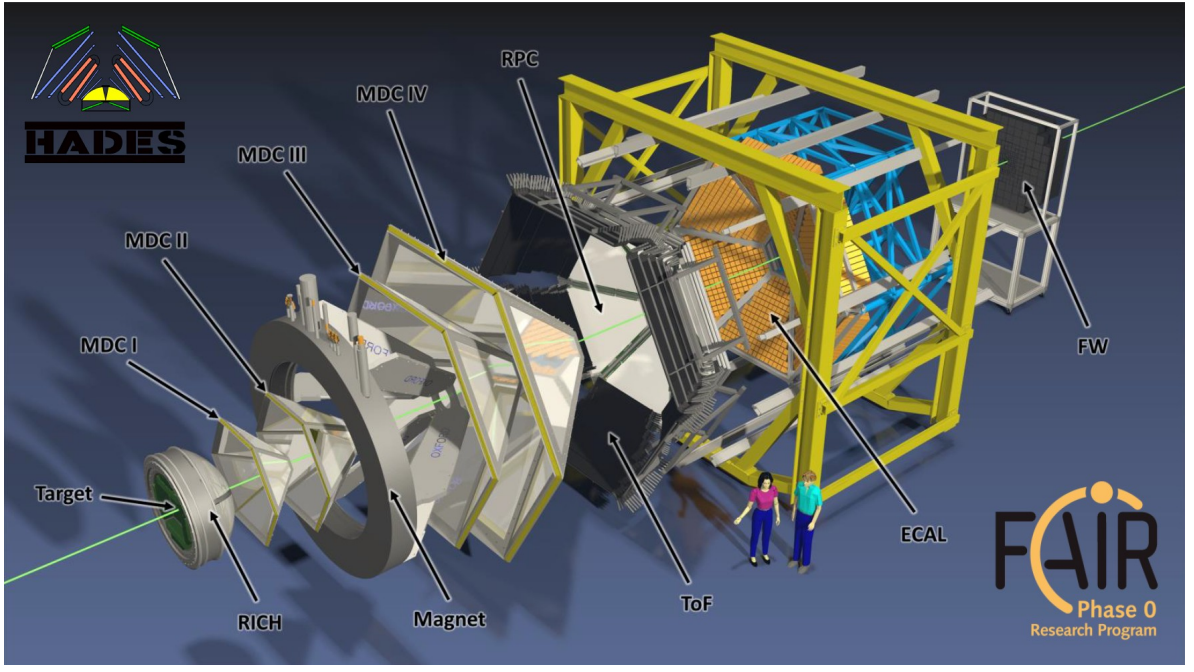
- Goal: measurement of $\pi^0 \rightarrow \gamma\gamma$ decay
- All spectra need efficiency & acceptance corrections
- Efficiency of photon detection can be measured with e+ or e-

- Acceptance must be studied

HADES experiment

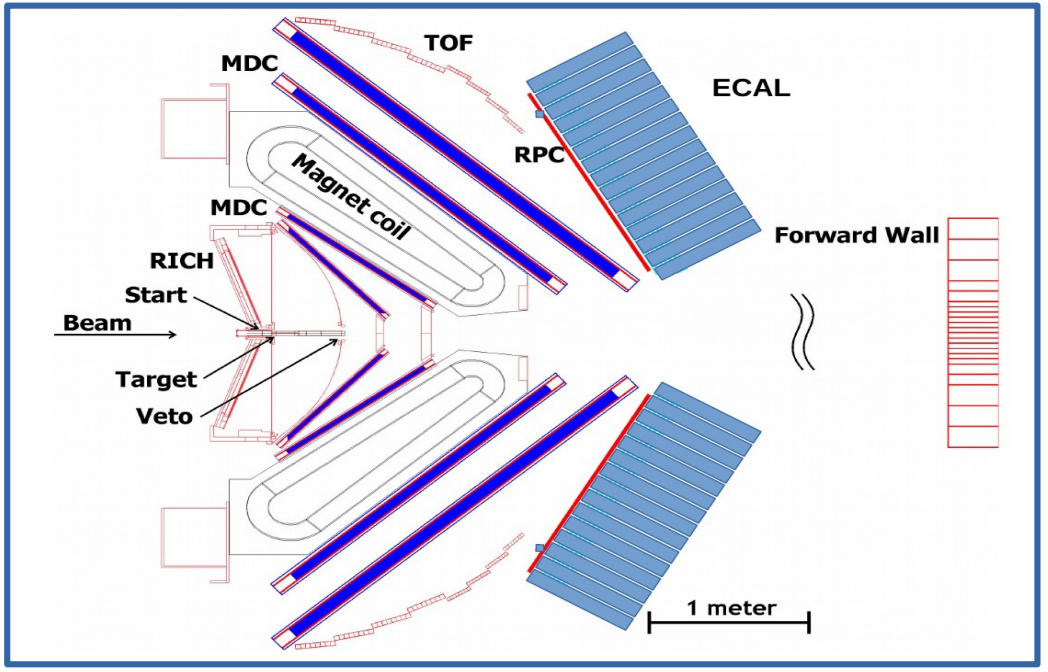
Fixed target experiment at SIS18, Darmstadt

- Beam energy 1-2 A GeV;
- π, p, heavy nuclei beams
- Covers full azimutal angle and $18° < \theta < 85°$ polar angle



HADES detector

- Tracking system
- Time-of-flight system
- Ring imaging Cherenkov detector
- Electromagnetic calorimeter ECal
- Forward hodoscope

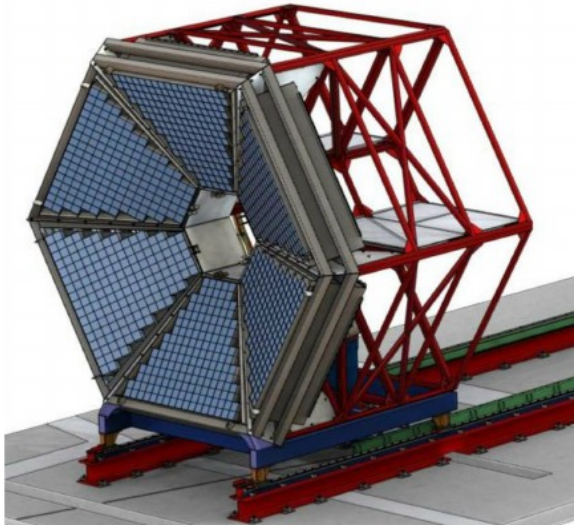


Electromagnetic calorimeter ECal

- Added to the setup in 2019
- Measure photons
- Improve e/π separation

- Energy resolution $\frac{\sigma_E}{E} = \frac{5\,\%}{\sqrt{E\,[GeV]}}$

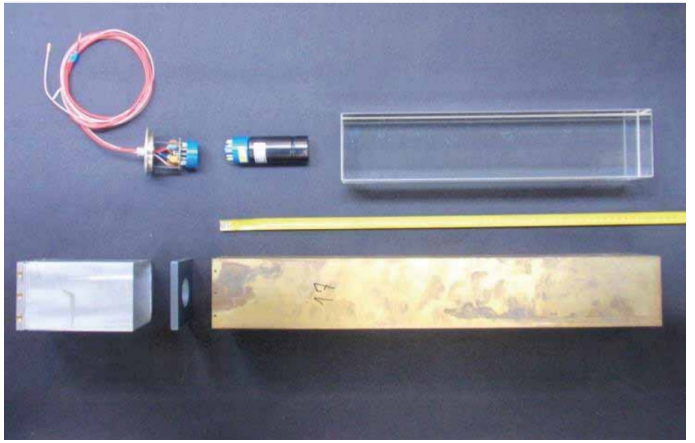
- Time resolution < 300 ps

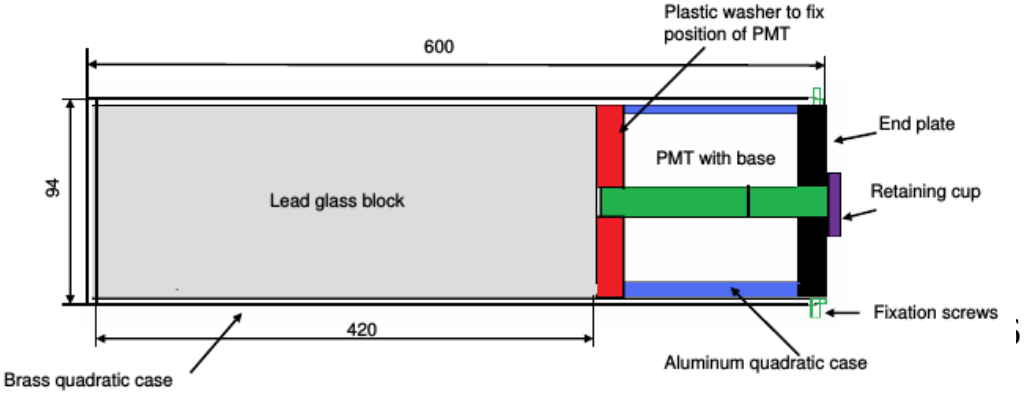


6 sectors covering
$12^\circ < \theta < 45^\circ$

The module of the ECal detector

- Cherenkov radiator made of lead glass (CEREN25), 16.7 radiation lengths
- PMT
  - 1.5 inch EMI 9903KB
  - 3 inch Hamamatsu R6091





Acceptance

1 way

- Definition of θ, φ acceptance of ECal detector
- Monte-Carlo simulation of $\pi^\circ \rightarrow \gamma\gamma$ decay
- Check if both photons are within θ,φ acceptance
- Calculate acceptance corrections

geometrical acceptance

2 way

- Monte-Carlo simulation of $\pi^\circ \rightarrow \gamma\gamma$ decay
- Full simulation of transport, ECal responce
- Analysis of data in the same way as in experiment
- Comparison of reconstructed number of π° with generated one

acceptance * efficiency

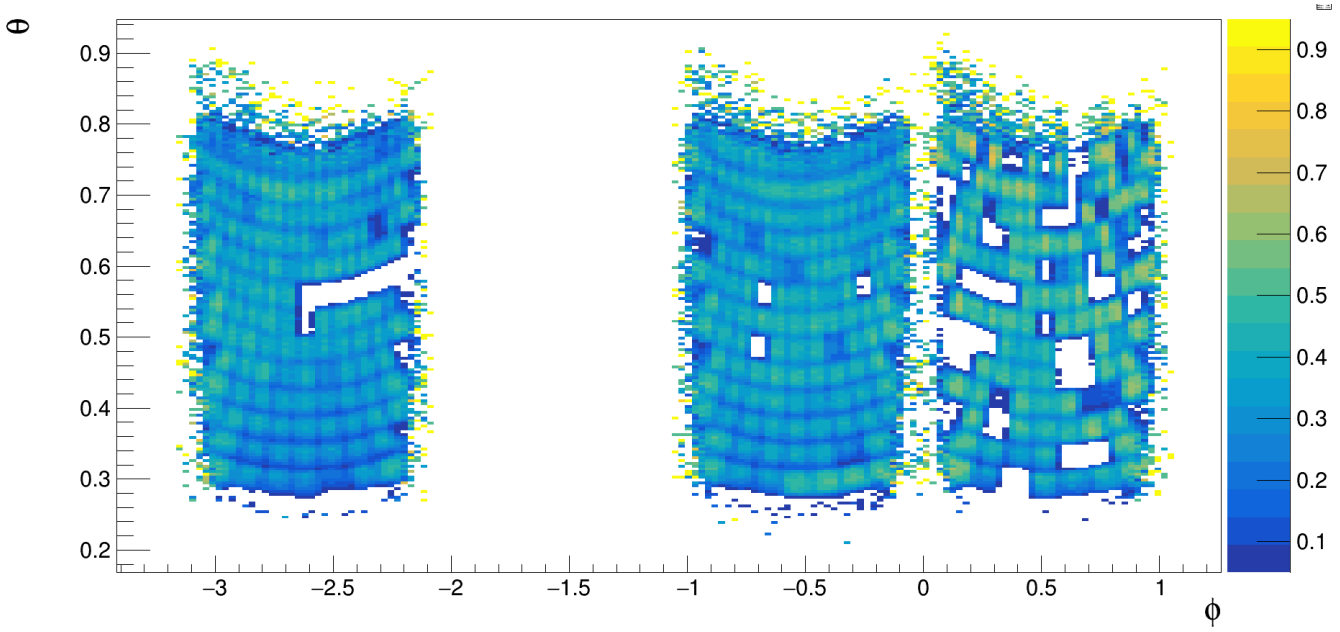
1 way

- Definition of θ, φ acceptance of ECal detector
- Monte-Carlo simulation of $\pi^\circ \rightarrow \gamma\gamma$ decay
- Check if both photons are within θ,φ acceptance
- Calculate acceptance corrections

Acceptance of photons of the ECal detector

- 0A current in solenoid
- all charged particles
- coincidence with ECal

- θ, φ map of the ECal detector
- without magnetic field trajectories are straight →the map describes photon detection



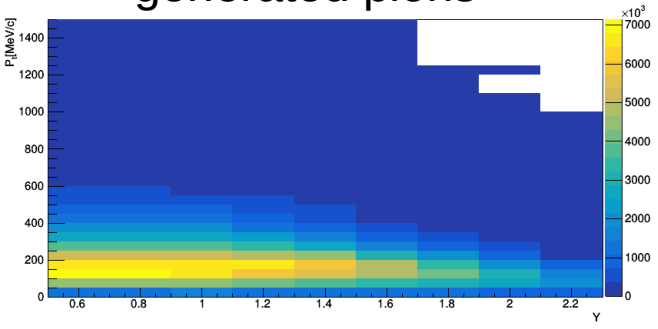
Acceptance of π°

π° are generated with UrQMD

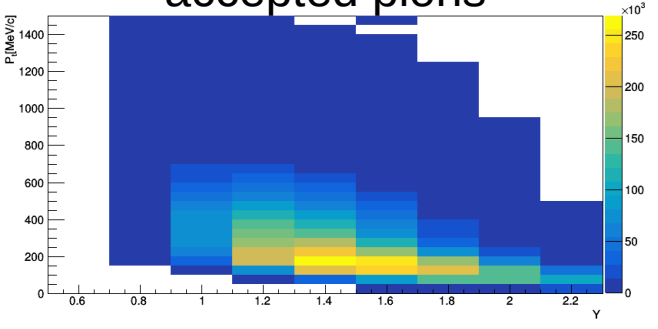
Isotropic decay to γγ

If both photons are within θ,φ of ECal → π° is accepted

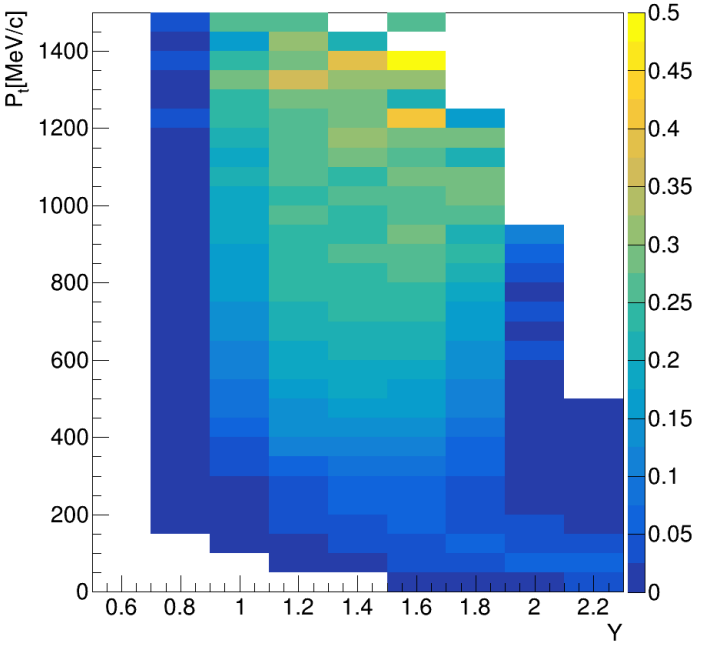
generated pions



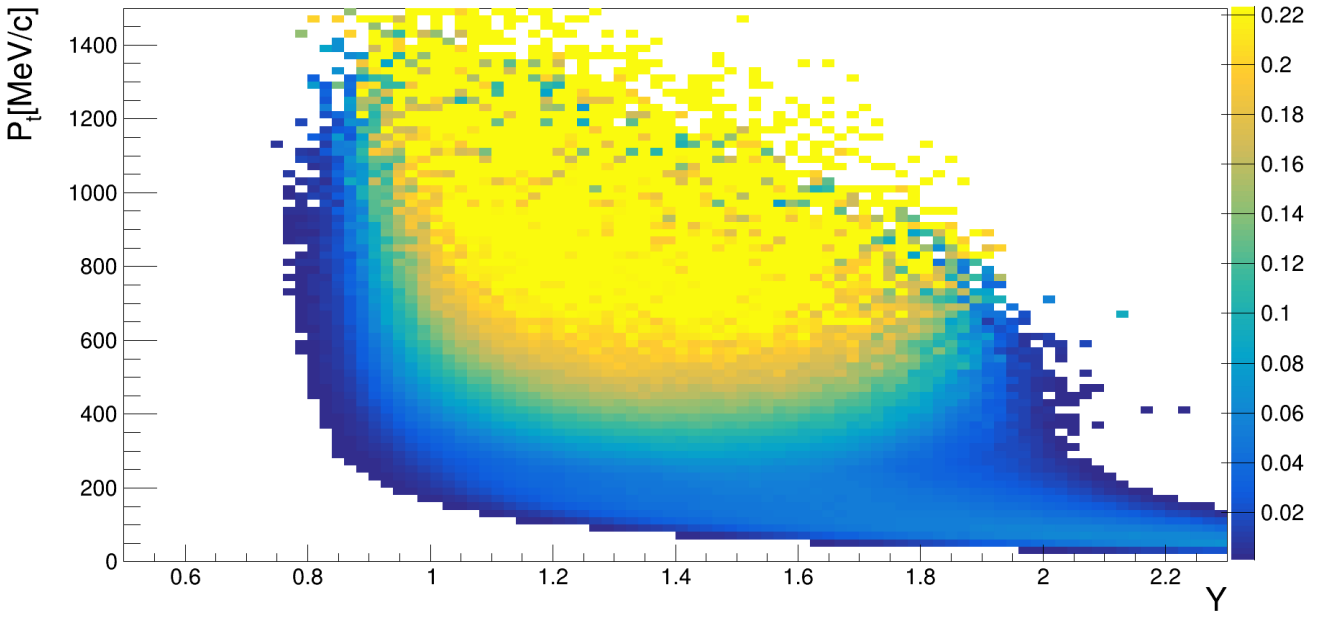
accepted pions



acceptance



More detailed acceptance



2 way

- Monte-Carlo simulation of $\pi^\circ \rightarrow \gamma\gamma$ decay
- Full simulation of transport, ECal responce
- Analysis of data in the same way as in experiment
- Comparison of reconstructed number of π° with generated one

Selection criteria

Selection of events

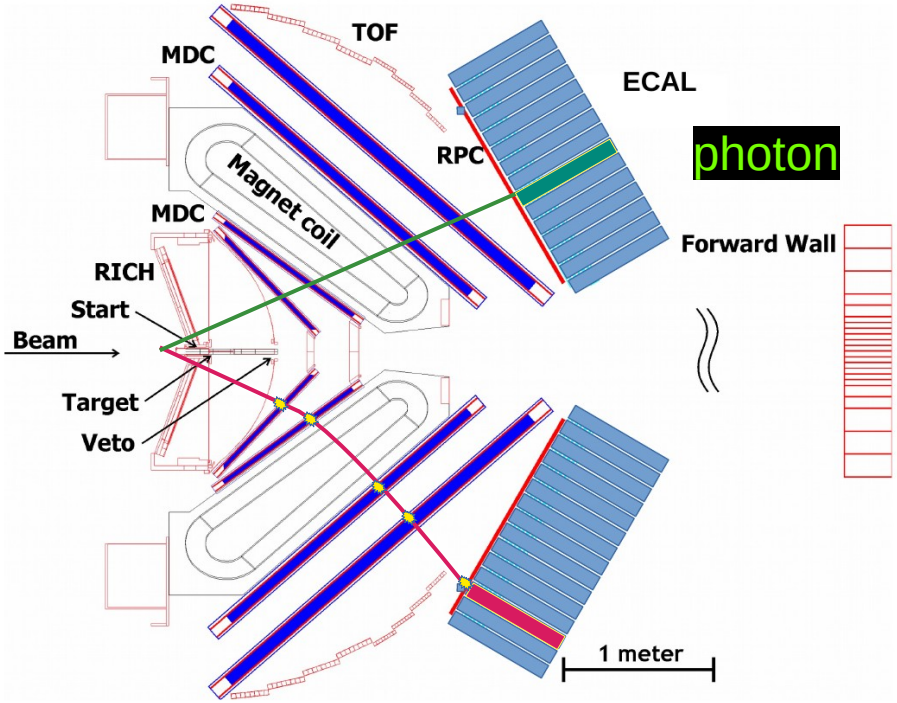
- centrality 0-30%

Photon:

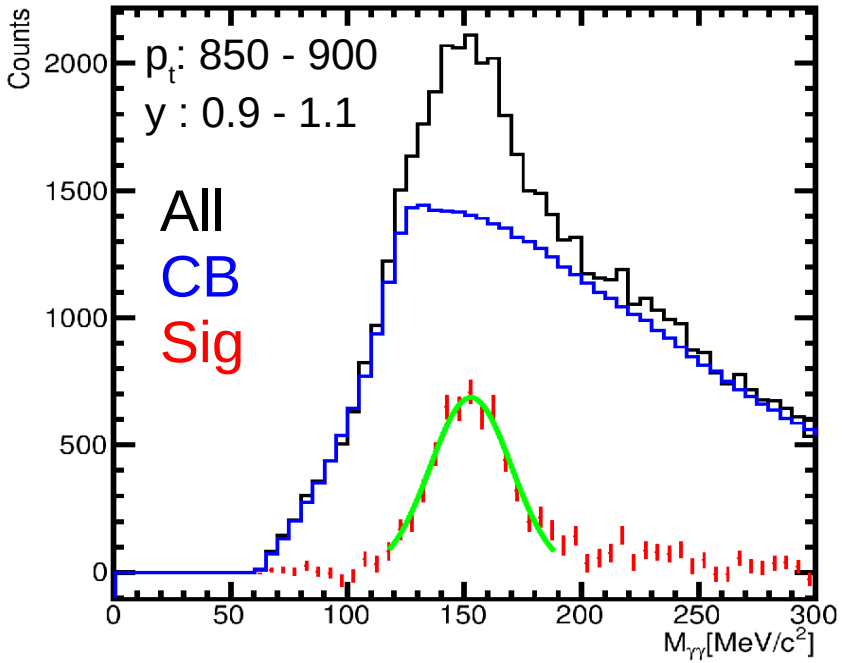
- No hit in RPC (closest detector to ECal)
- No match with any track
- $0.9 < \beta < 1.1$
- E > 100 MeV (reject neutrons)

Diphoton:

- Opening angle > 10°

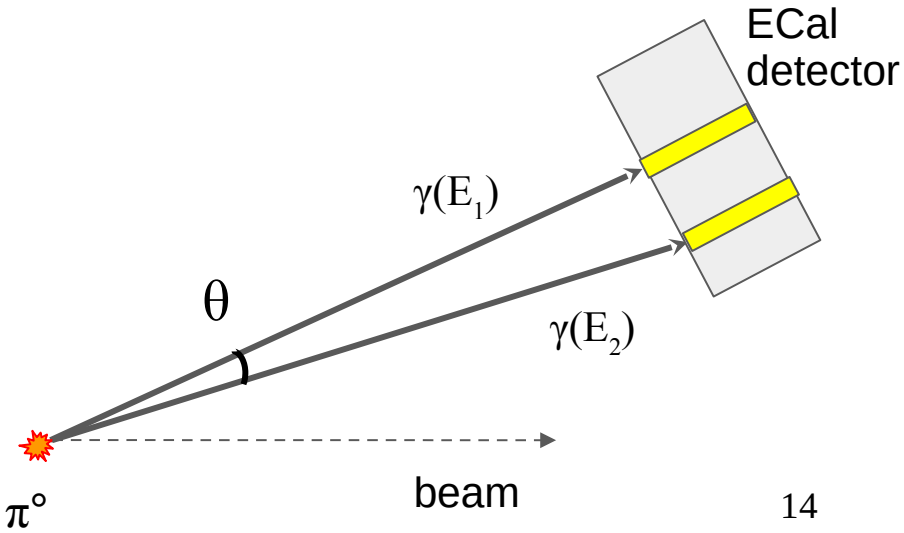


Reconstruction of π^0-mesons

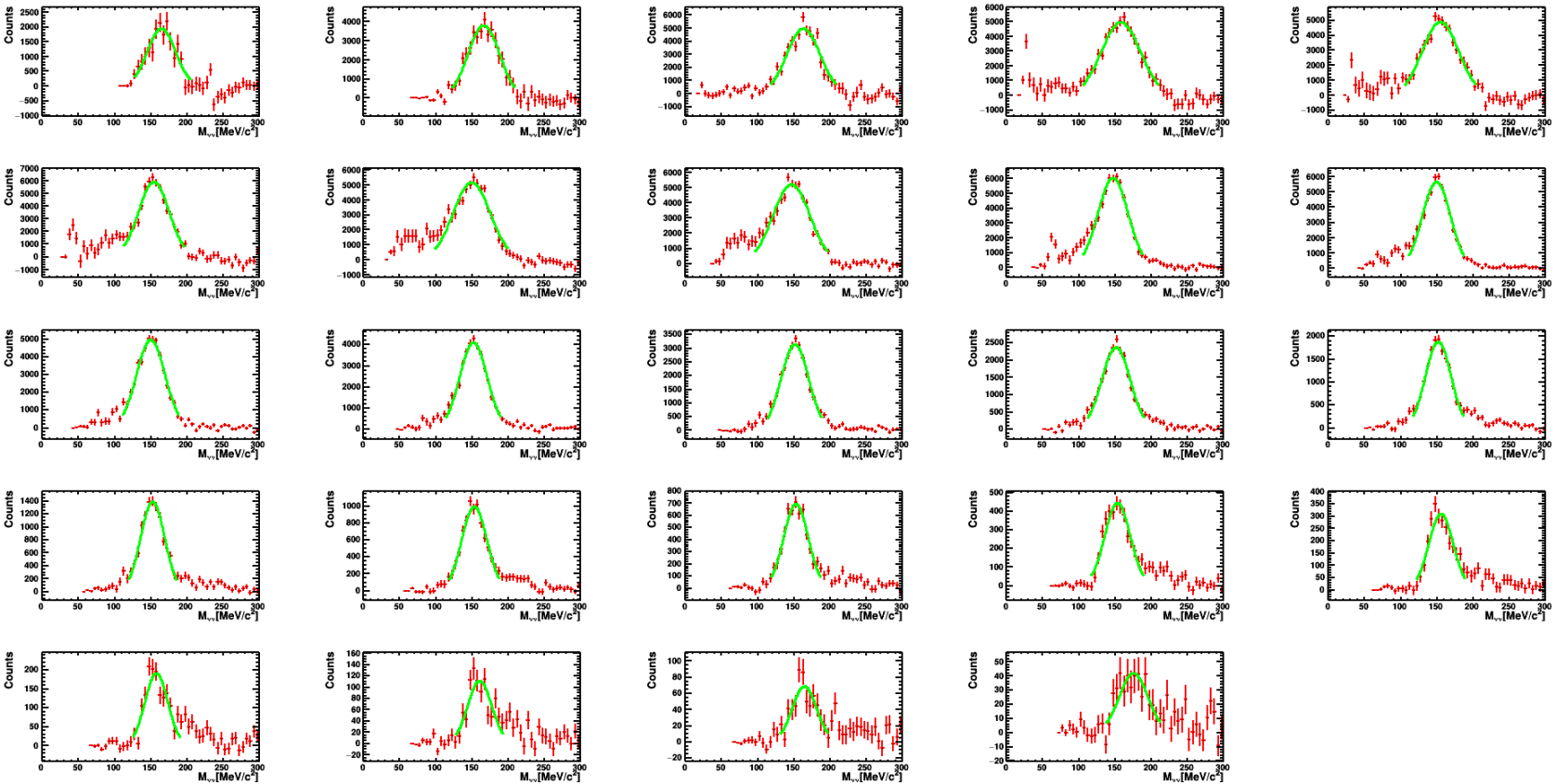


All – experimental data
CB – mixed-event combinatorial background
Sig – signal
Signal is fitted with Gauss

$$m_{\pi^0} = \sqrt{E_1 \cdot E_2 \cdot (1 - \cos\theta)}$$

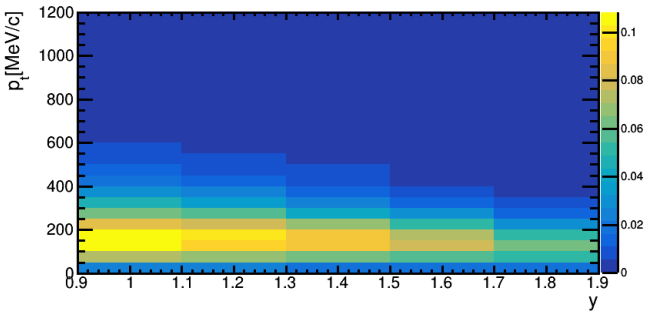


0.9 < y < 1.1

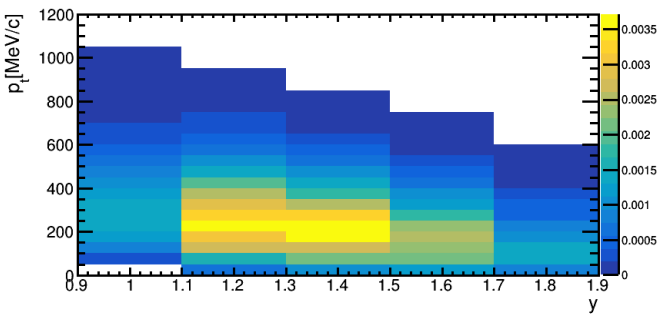


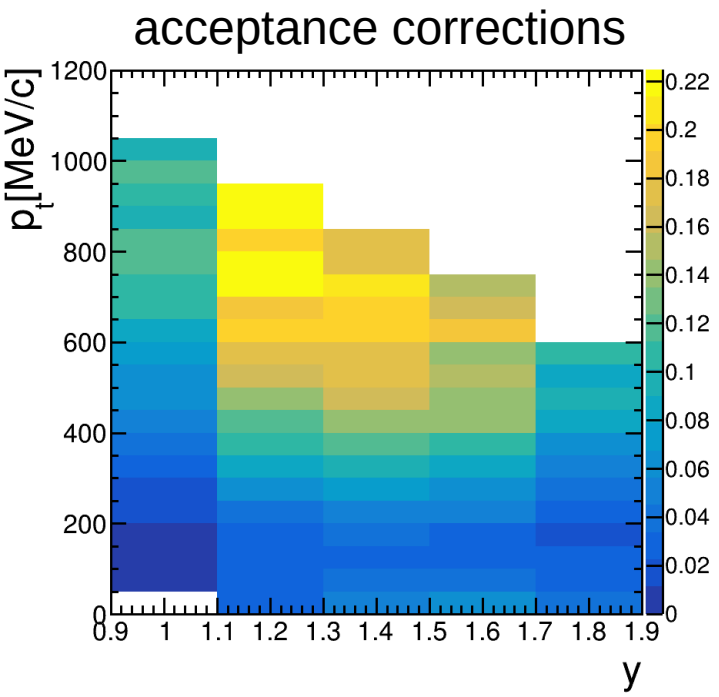
Acceptance corrections

UrQMD generated number of pions within pt-y bin per event

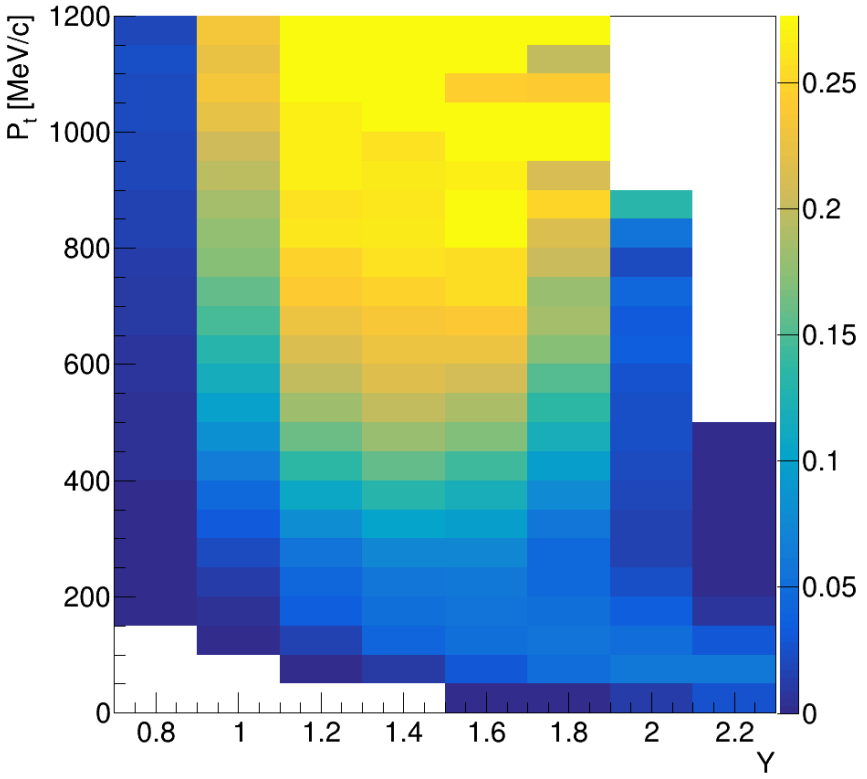


Reconstructed from **simulation** number of pions within pt-y bin per event



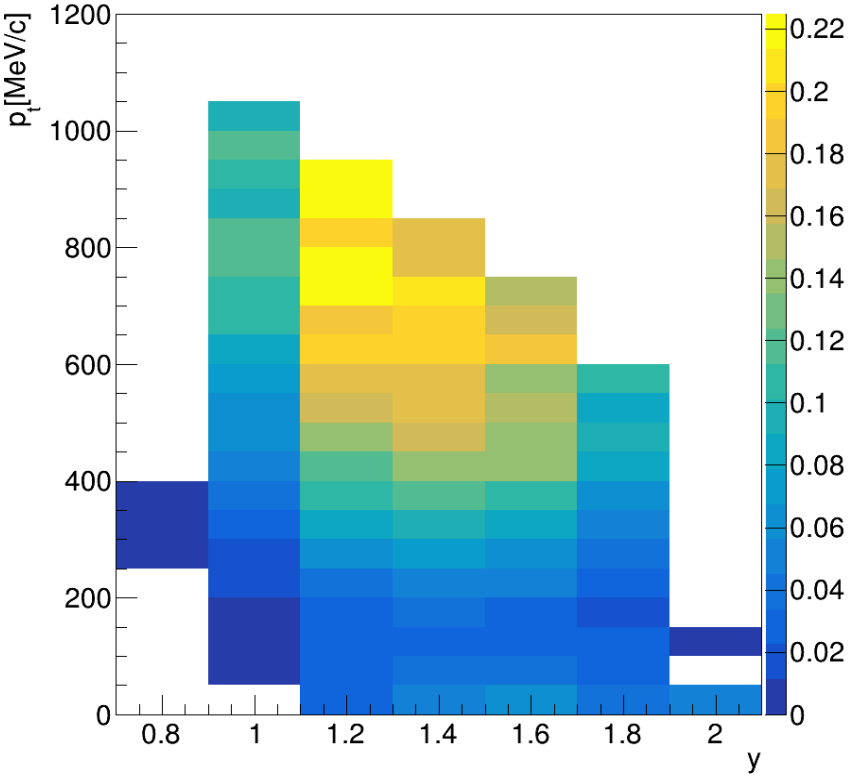


Acceptance
(pure geometry of ECal)



1 way

Acceptance * efficiency
obtained with full Geant simulation

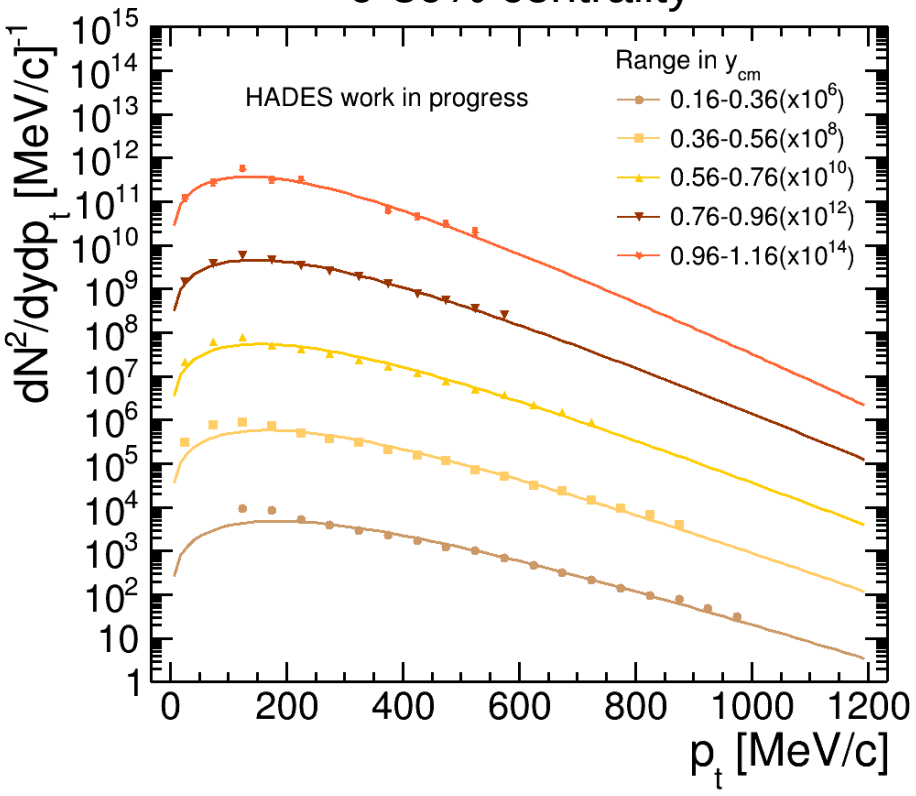


2 way

Extraction of π^0 yield

$$Ag + Ag\ \sqrt{s_{NN}} = 2.42\ A\,GeV$$

0-30% centrality



Extrapolation to p_t range which is not covered by acceptance of ECal:

$$\frac{dN}{dp_t} = C\ p_t\ m_t e^{-\frac{m_t}{T}}$$

(Boltzmann fit)

Full π^0 yield per event

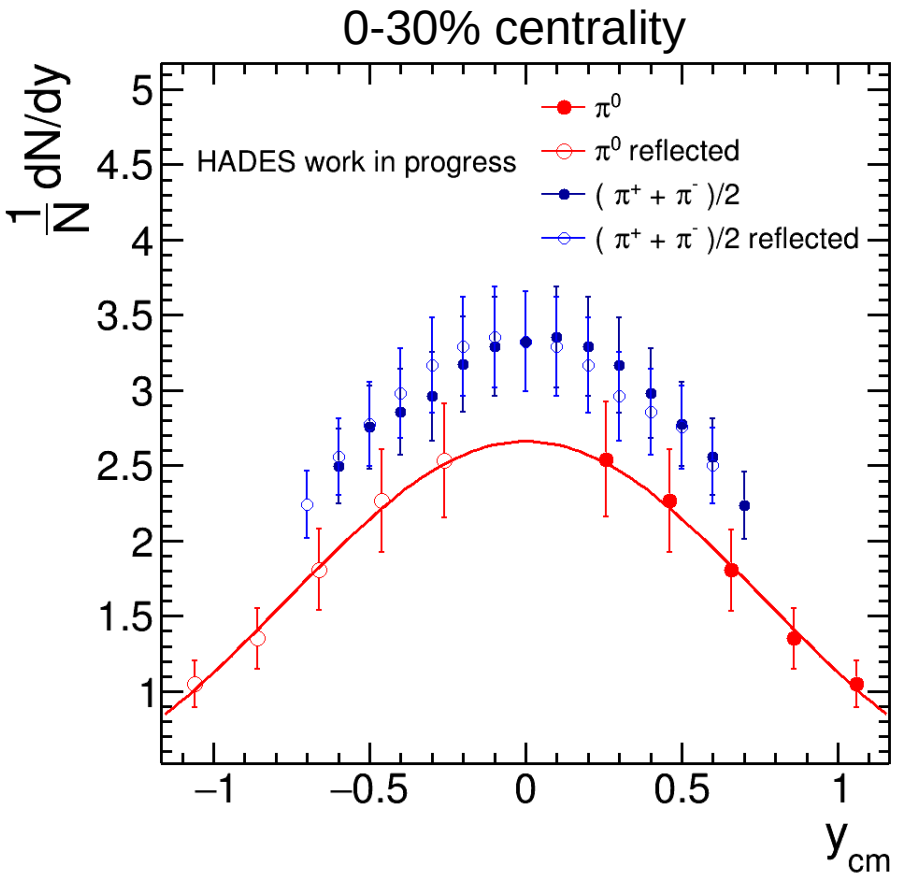
$$Ag + Ag\ \sqrt{s_{NN}} = 2.42\ A\,GeV$$

Extrapolation to y range which is not covered by acceptance of ECal:
Gauss fit

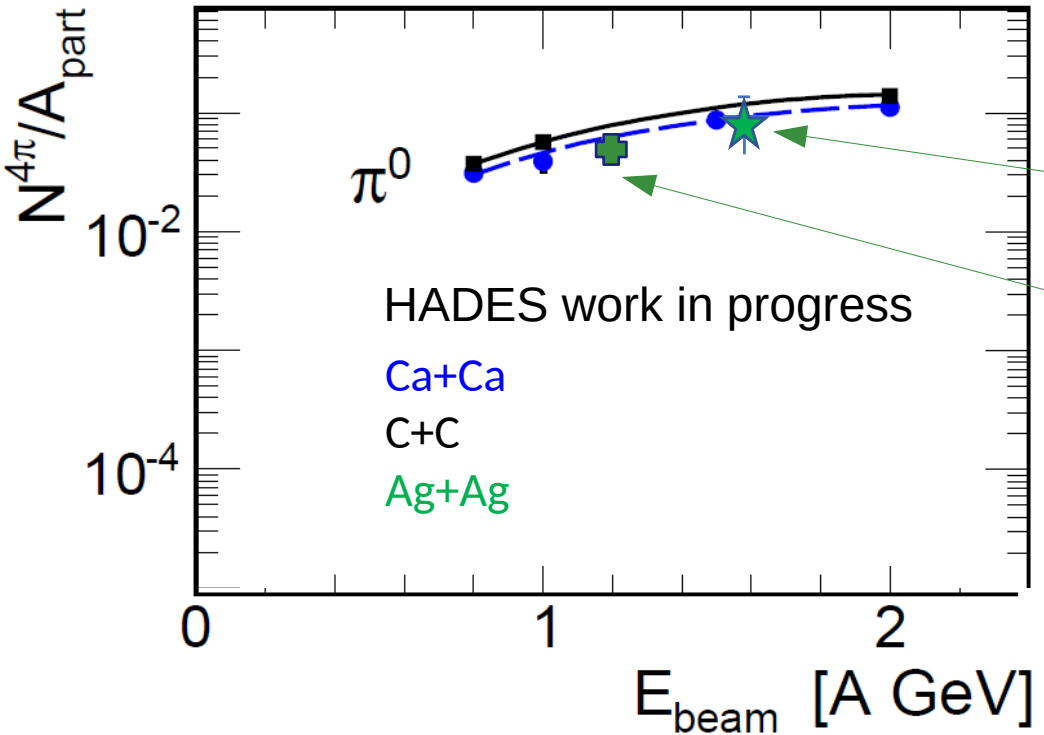
$$\frac{N_{\pi^0}}{N_{events}} = 5.1 \pm 0.3$$

preliminary estimate of systematic error: ~15% due to efficiency determination

$(\pi^+ + \pi^-) / 2$ is drawn for comparison



Comparison to the world data



HADES Ag+Ag 1.58 A GeV beam energy

HADES Ag+Ag 1.23 A GeV beam energy

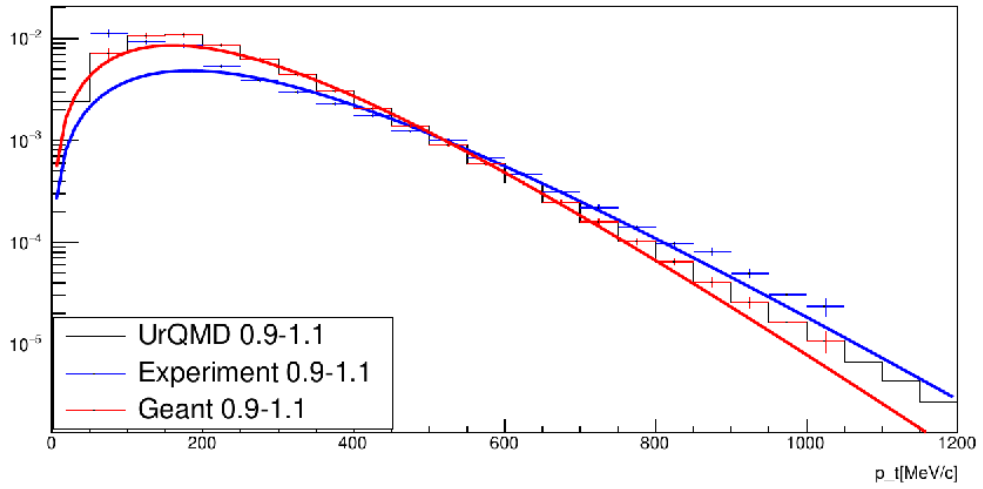
$N_{\pi 0} / A_{part} = 0.043 \pm 0.005$

Summary

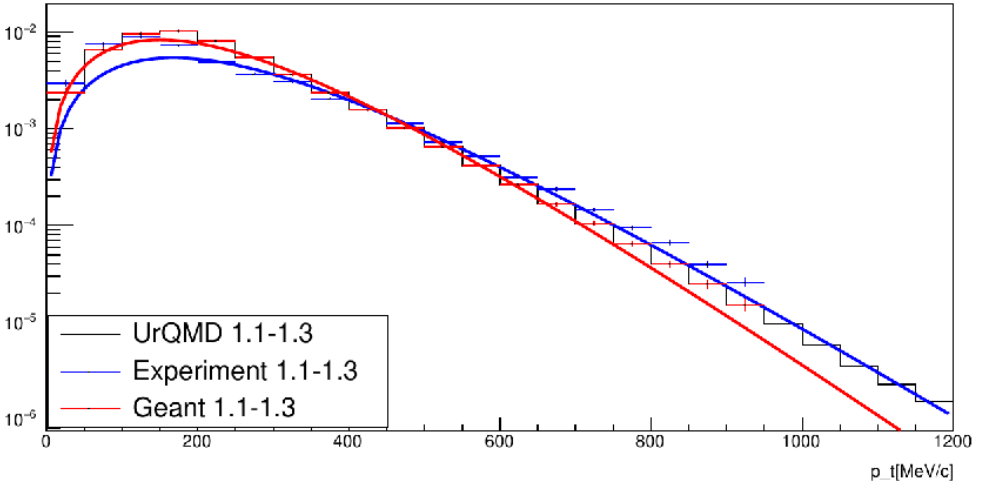
- Acceptance corrections are calculated using two different techniques
- Efficiency of detection of photons by the ECal detector must be studied
- The preliminary results corrected to acceptance show good agreement with the world data

Thank you for your attention!

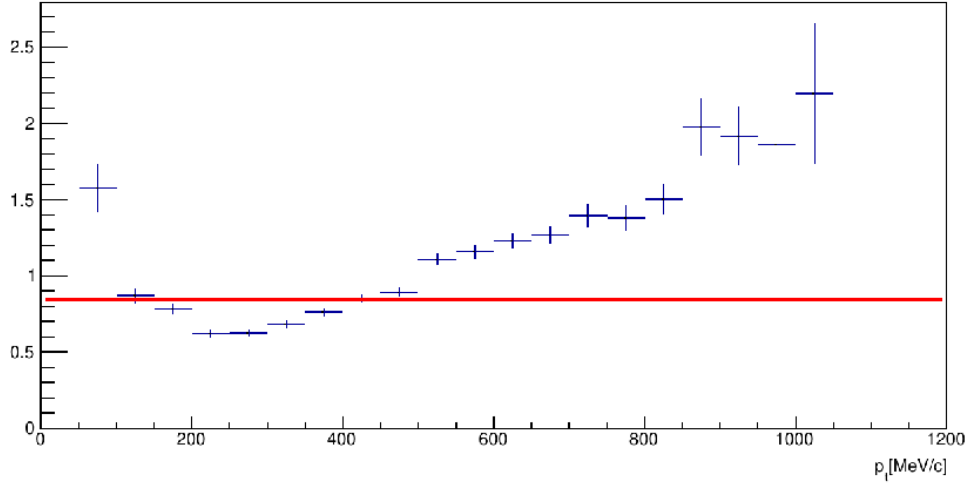
UrQMD 0.9-1.1



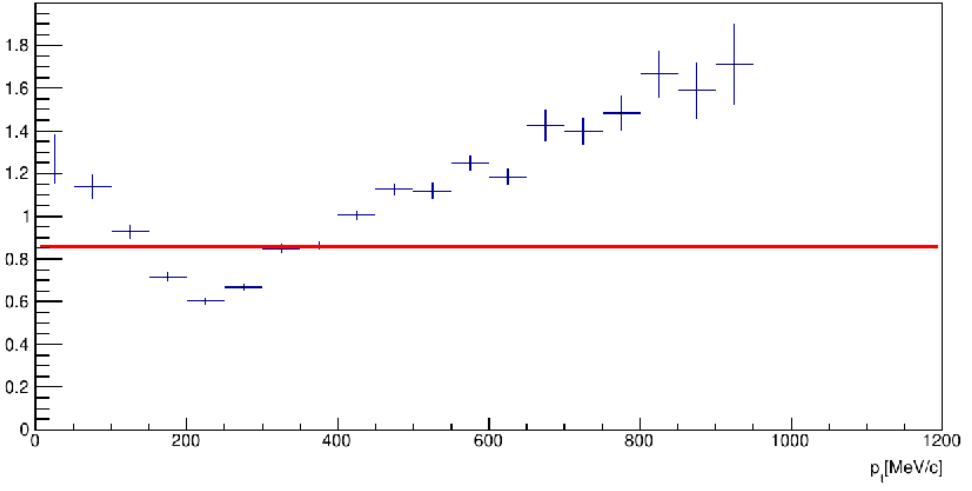
UrQMD 1.1-1.3

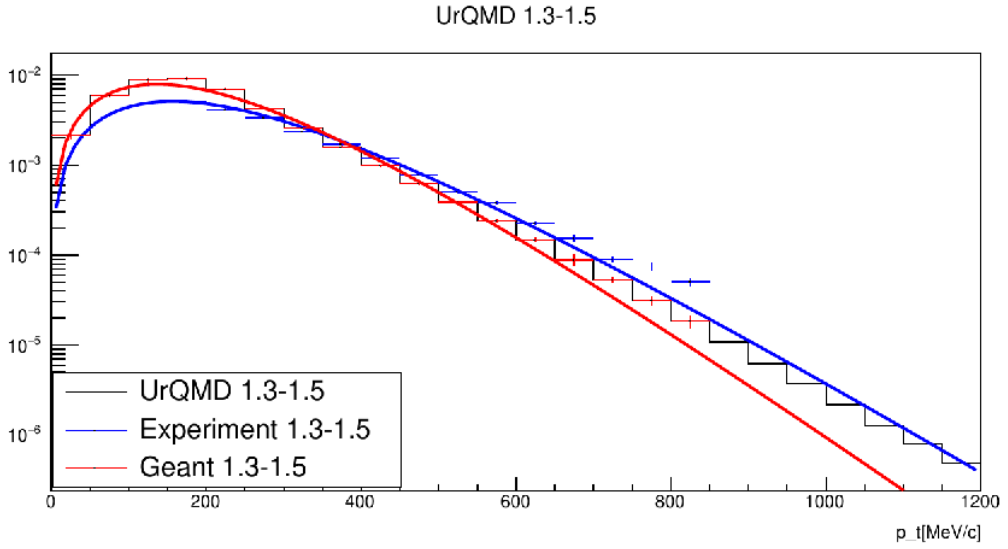


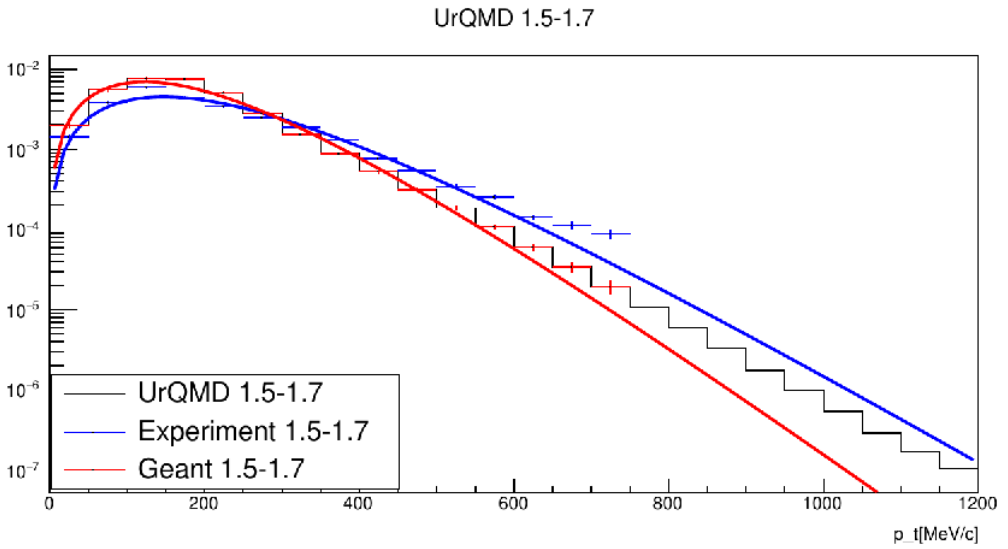
Exp / Geant

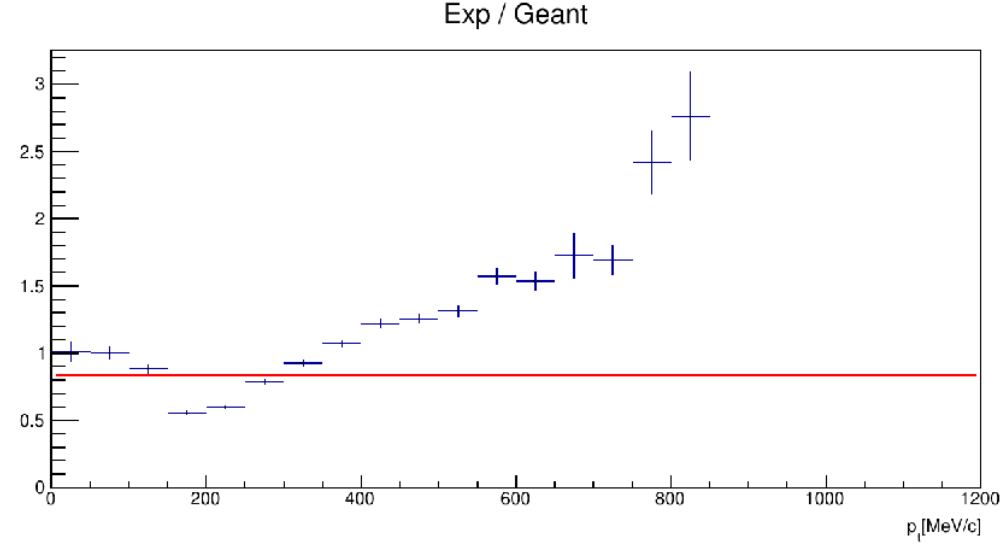


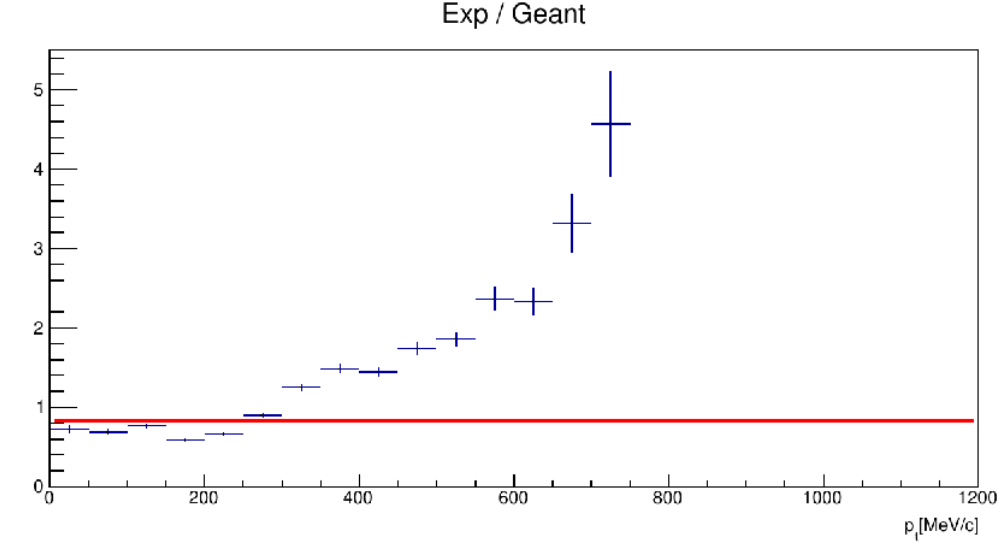
Exp / Geant

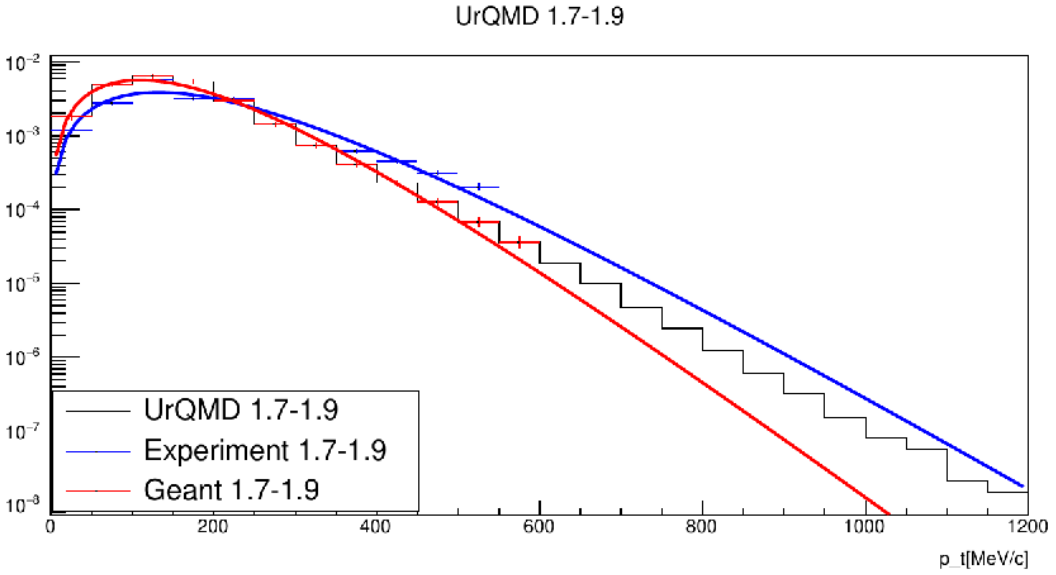


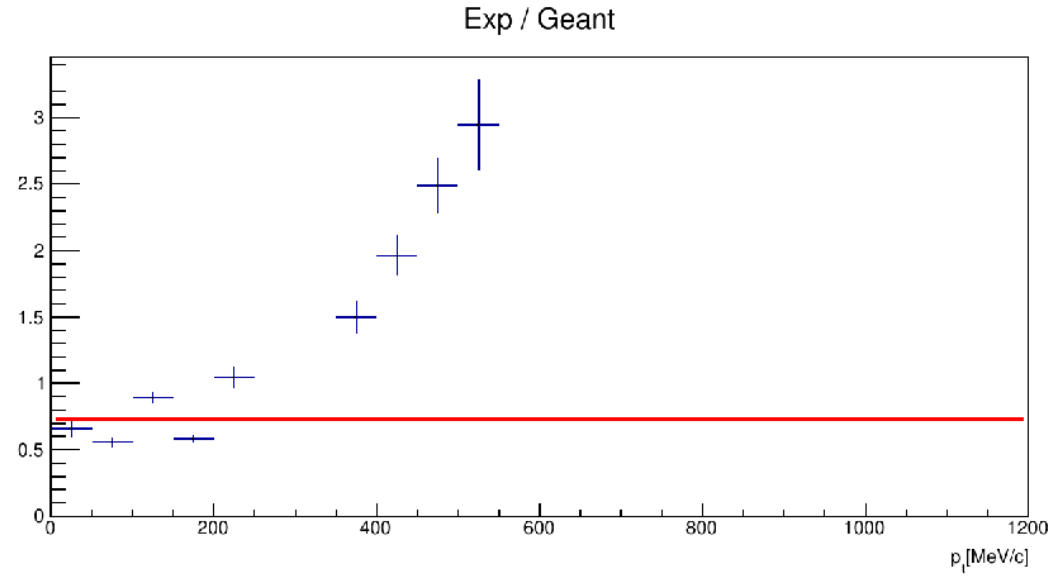

UrQMD 1.3-1.5
UrQMD 1.3-1.5
Experiment 1.3-1.5
Geant 1.3-1.5
p_t[MeV/c]


UrQMD 1.5-1.7
UrQMD 1.5-1.7
Experiment 1.5-1.7
Geant 1.5-1.7
p_t[MeV/c]


Exp / Geant
p_t[MeV/c]


Exp / Geant
p_t[MeV/c]


UrQMD 1.7-1.9
UrQMD 1.7-1.9
Experiment 1.7-1.9
Geant 1.7-1.9
p_t[MeV/c]


Exp / Geant
p_t[MeV/c]

Comparison to UrQMD